

HUMUS ACCUMULATION AND SOIL FORMATION IN SVALBARD

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1. A few climatic data

Svalbard belongs to the permafrost region. The greatest registered depth of frozen soil is 450 m (Liestol, 1977). The average annual temperature is of course below 0°C. Large areas seem to have temperatures between -4.5 and -6.0°C. There is a tendency towards increasing temperatures in recent times (Steffensen, 1982).

The amounts of precipitation are low. At the mount of Isfjorden (Isfjord Radio) the average annual precipitation is found to be slightly more than 400 mm. Longyearbyen has a little more than 200 mm. A short series of observations at the mine Svea seems to show a value of about 180 mm. The precipitation is still considerably lower at many other places.

2. Development of soils profiles

Soil formation in the permafrost regions is influenced by special factors. In the summer time a shallow surface layer, often a few

decimetres, thaws out. The water regime in this active stratum is characterized by the still frozen ground underneath.

Owing to the low summer temperature the production of plant material can not be high. Without addition and transformation of organic matter soil profiles can not be developed. Because of this it is logical to emphasize amounts and properties of humus when classifying permafrost soils.

To be situated so far north, Svalbard has a rich flora. There are about 170 vascular species here (Ronning, 1979). A large number of mosses and lichens occur. At many places algae are found on the soil surface. In all likelihood the algae play a relatively important role as producers of parent material for humus.

Some species of bluegreen algae are able to fix nitrogen. Because Svalbard lacks leguminous plants, the nitrogen fixing algae are of special interest.

When I started the soil investigation in Svalbard in 1977, I was anxious to know more about the algae vegetation. After some time I came in contact with the specialist Olav M. Skulberg, Norwegian Institute for Water Research, and collected a number of algae samples for him. It became apparent that some of the samples contained species which had not been described before. Original descriptions will appear in the near future.

3. Some special soil-forming processes

Intense mixing of the upper soil layers due to freezing and thawing occurs in many places in the permafrost regions. Cryoturbation is a name used frequently for these processes.

In slopes a slow movement of the upper soil layers can take place. The word solifluction is used to describe this phenomenon (Andersson 1906). During thawing this process is especially pronounced. Solifluction leads to mixing of soil matter. On some occasions humus layers can be buried deeper in the soil profile. There exist transitions from solifluction to slips and landslides.

In nearly horizontal landscapes with finegrained mineral matter, gley formation can develop. Along fissures and root channels the atmospheric air can, in summer time, come in contact with the temporary ground water dammed up by the permafrost. The ferrous ions can be oxidized to ferric ions and then be precipitated in rustlike compounds.

Because of the low snow and rainfall, salts may be crystallized on the soil surface during dry summer periods. Such salt crusts occur especially where the soil has good capillarity, and are most easily found where plants are absent. In many places calcium sulphate dominates in such salt precipitations. Near the sea level easily soluble

sodium compounds also occur. The salt incrustations often have a bright white colour, and may at a distance look like snow.

On the shore areas and in open valleys large continuous wetlands are found. But the growing conditions are, as a rule, not sufficient for the formation of much organic matter.

In many places up to active glaciers and along rivers and brooks the surface soil material is deposited so recently that the plants have not had enough time to establish a vegetation cover.

4. *Humus accumulation in steep slopes*

Svalbard has a number of moss species which under favourable conditions can be a basis for peat formation. However, most of the large wet areas have, as mentioned, poor growing conditions for plants.

In slopes the water liberated by thawing of a surface layer during the summer, will percolate on the surface of the still frozen ground. Such moving water contains as a rule more oxygen and nutrients than stagnating water, and may be a basis for a relatively luxuriant vegetation. Where the local climate is favourable, and the soil surface receives extra nutrients in bird droppings, peat producing plants can grow so fast that large amounts of organic matter can be accumulated.

In well known old textbooks it has been pointed out that real peatlands are lacking in Svalbard. An intention may have been to exclude the large wet areas as peatlands. According to an international definition peatland is landscapes with at least 30 cm deep surface layer of peat (Third Meeting... 1938). During my first visit to Svalbard, in 1977, I looked for peat formations in slopes, and happened to find such deposits in the neighbourhood of Grumantbyen (Låg, 1980, 1988a). Later I urged people who use to travel in Svalbard a lot, to watch for such phenomena, and have recieved some tips.

At the mountain peak Alkhornet, at the northern side of the mouth of Isfjorden, a similar peat deposit as that near Grumantbyen occurs (Låg, 1990a). Here at Alkhornet the peat cover has been less exposed to erosion than that in the neighbourhood of Grumantbyen. However, in a cut after a small slip a peat depth of 1.5 m has been measured, and a sloping of the surface up to 1:1 (45°). Near Grumantbyen a depth of the peat of 3 m, and a sloping up to 1:1.1 (42°) has been registered (Låg, 1988a). At both places the peat surface is supplied with bird droppings.

As a rule the peat will not thaw up deeper than 0.5–1 m during the summer time. The deeper peat will accordingly be frozen permanently. The permafrost situation of the peat has not prevented further growth.

The peat covered areas at Alkhornet and Grumantbyen are some

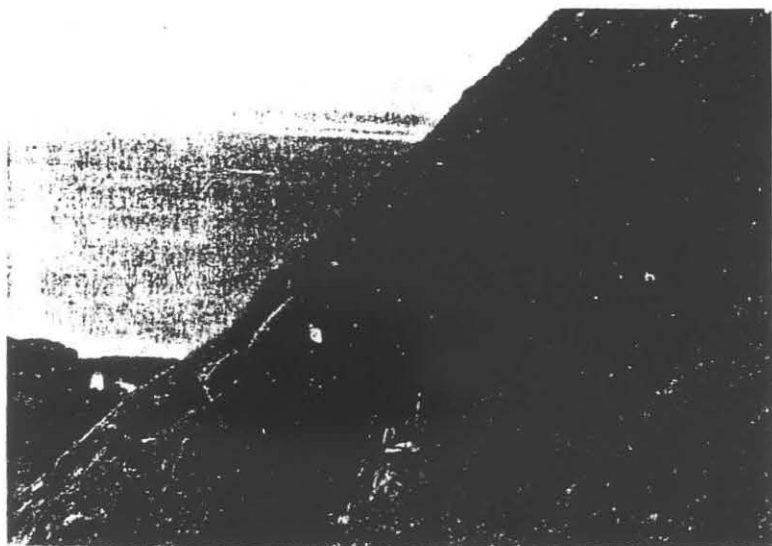


Fig. Very steep peatland, Alkhornet. Photo J.Låg, July 24, 1989

hectares in size. Both localities are well exposed for those travelling in the Isfjord region. Scattered occurrences of peat in steep landscapes are discovered at other places in the same district, e.g. northeast of Fredheim at Sassenfjorden.

In a private letter dated 09.06.1987 the Canadian lady Catherina LaFarge-England wrote that she had discovered a 4 m deep peat deposit with the surface sloping 34° , in the Ellesmere Island, about 82°N . Probably similar occurrences exist at many other places in the Polar regions.

Small areas with peat in horizontal or gently sloping landscapes have been found at several places in Svalbard.

5. Humus accumulation and soil classification

Formations of deep deposits of peat show interesting processes of soil development at special places in the permafrost regions. Also where the accumulation is less pronounced, the humus formation is an important mark of soil development.

In connection with the preparation of a schematic soil map of Svalbard, classification systems had to be evaluated. A difficult question to settle was which claims should be fulfilled before we can say a

soil profile is developed. A minimum supply of plant litter, and total amounts of organic matter in the soil, seem to be exact starting points. So far we need more analytical figures. We should try to get more data on humus content, e.g. gram pr.m². As a preliminary method of work a vegetation cover of at least 5% has been suggested when deciding the soil profiles in an area. In addition to vascular plants, mosses and fruticose lichens are included when vegetation is regarded in this connection. However, more comprehensive registrations are still needed.

For classification purposes the intermixture of the humus in the mineral matter is also emphasized. A quite common soil group has a very limited mixture of organic and inorganic material. The name humus cover soils has been used for this group.

One group of soils has plant roots more or less evenly distributed in the profile, and often a brownish colour due to oxidized iron compounds. Brown earth and brown soil have been used as names. The development of the root systems is an important cause for distribution of organic matter in the profile (Tedrow 1977). In permafrost districts animal organisms are not very active mixing material. This is different from the situation in warmer climates. Cryoturbation, solifluction and slips ensure a mixture of soil material, but humus matter is often distributed more unevenly.

The degree of decomposition can vary a lot from place to place. The plant debris is often only slightly changed. In the deep peat deposits at Alkhornet and Grumantbyen plenty of tissues of mosses are found. Species of the genera Aulacomnium, Polytrichum, Drepanocladus and Calliergon are well represented. Tissues of Sphagnum species are not very common. The degree of decomposition according to von Post (1921) 10 steps scale was often 2-4. Determination of nitrogen and loss of ignition gave the possibility to calculate of the C:N-ratio. In most cases the figures were between 20 and 50.

A locality at Mitherhuken, with a moderate sloping, had very well decomposed organic matter. The decomposition degree was evaluated to be 7-8, and the nitrogen contents in three samples were determined to be higher than 2.0% (Lag 1980). In a similar way as at Alkhornet and Grumantbyen, the peat surface received droppings from birds which had nests in the neighbourhood.

6. The notion desert in connection with polar regions

From time to time we can find the term desert used for areas without plants or with very sparse vegetation in permafrost regions. It seems, however, more convenient to limit the use of this word to

the very dry areas. In the permafrost districts the temperature is, as a rule, a limiting factor. Compared with the deserts not far from the equator, the humidity is not extremely low even if the amounts of precipitation are 100–200 mm.

It should have been an easy way to work to put in a group called deserts all the areas without vegetation or with a very limited plant cover. But it seems more in agreement with the ideas of soil classification to try to evaluate the development of the soil profiles, including the amounts and properties of humus.

7. Importance of nutrient supply for production of organic matter

Even in the extremely cold climate in the permafrost regions the supply of nutrients is of importance for the plant production. Under the nesting cliffs it is very easy to see positive reactions to droppings from the birds.

In Longyearbyen they wanted to make their landscape greener. Some elementary fertilizer and lime experiments and a few plots with different species and varieties of grasses were prepared (Lag, 1988b, 1990b). The grass species *Festuca rubra* and *Poa pratensis* have been found to be very suitable. Experiments with cultivation of Svalbard poppy (*Papaver dahlianum*) and the grass species *Alopecurus alpinus* have been started. Nitrogen fertilizer resulted rapidly in a positive response. This experience gave still more support to the opinion that nitrogen fixation of bluegreen algae is important for the plants in Svalbard.

SUMMARY

Large areas in Svalbard have average yearly temperatures of -4.5 to -6.0°C and precipitation 200–300 mm. The deepest measured permafrost is 450 m. To be situated so far north, the vegetation is rich in species.

Svalbard has no leguminous plants. The power of bluegreen algae to fix nitrogen is supposed to be important for the vegetation.

The content and properties of humus are important factors to take in consideration when the soils are to be classified. Cryoturbation, solifluction, slips and landslides are effective factors in soil formation. In relatively favourable areas arctic brown earth is developed. During dry summer periods salt crusts can be formed on soil surfaces over large areas.

Deep peat deposits have newly been discovered in steep slopes. The deepest measured peat is 3 m, and the steepest surface of the peat layer 1:1 (45°). These curious peat accumulations show that specific soil-forming factors are active, and that considerable possibilities for plant production have existed here.

Such strange types of peat deposits occur probably in many places in the permafrost districts.

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